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WHAT MATHEMATICAL SUBJECTS SHOULD BE INCLUDED IN THE CURRICULUM OF THE SECONDARY SCHOOL? FROM THE POINT OF VIEW OF THE TECHNICAL SCHOOL.

BY ARTHUR S. HATHAWAY.

After careful consideration of this question, it has appeared to me that any changes in the present curriculum of secondary schools in mathematical subjects should be not in the subjects taught, but in the object and character of the instruction. What the technical student most needs is a working knowledge of arithmetic, algebra, and geometry. He should be able to make ordinary arithmetical computations with accuracy, perform ordinary algebraic operations without making those numerous blunders which result from a confused perception of their arithmetical foundation, and have a store of geometrical facts and principles fixed in his mind by having logically worked many original exercises.

In fact, mathematical analysis is to the technical man merely a tool or instrument for doing his work, of which he must have not only the knowledge and understanding but also the expertness which he has with other tools. The purpose of a variety of topics and problems should be to give the necessary drill in fundamental operations without making the task too dull and grinding, just as in manual training, we give the pupil some piece to make, not for the purpose of having that piece made, but in order that he may learn to use the tools which it requires.

To seek expertness and accuracy in the use of mathematical operations is not opposed to the idea that mathematics is the highest type of logic and reason. No one can become accurate in the manipulation of mathematical symbols without understanding and following some good form of reasoning for every step of the work. The good workman can explain every step of the process by which he does a certain piece of work, how it is begun and how finished, the different tools that should be used, and why. He can also explain the mechanism of his tools and expound on the principles by which they work. In fact, the technical school requires that knowledge of elementary mathematics which is professional and not amateurish, because it is deeper and more thorough.

There is too much formalism, and not enough of thought and understanding required of the pupil. Students seem to be taught that a proposition is not demonstrated or a problem is not solved, unless it is done in a certain formal way, and any appeal to his common sense is doubtfully regarded. Facts are discovered in mathematics as they are in physics and chemistry. Verification is the best of all proofs.

The student who is thoroughly drilled in elementary arithmetic, algebra and geometry, will find that he has acquired the fundamental basis of all higher mathematical work. Higher algebra and trigonometry are only new pieces which are constructed with these elementary tools. Analytical geometry and the calculus bring the first great change to his method of work by the introduction of problems of variation. The purposes for which he has used the elementary mathematics are changed, and although all of it is still used, he is not clear as to the whys and wherefores. By continually testing the firmness with which the new ideas are built upon thoroughly familiar foundations, he soon gains confidence in the reality of the new outlook, and learns that keen insight into natural phenomena is one of the fundamental developments of the new subjects. For mathematics contains the vital elements of engineering knowledge, so that great mathematicians have often been notable engineers from the time of Archimedes down to the present.

When the question of elementary mathematical instruction for technical schools is answered by the declaration that its leading object should be to produce a pupil who is thoroughly drilled in the elementary processes, and able to use them as a workman does his tools, the other questions as to what topics should be in the curriculum, and whether problems should be of the old or modern type, resolve into the questions as to what topics and problems cover the necessary ground, and best arouse the interest of the student. It will be dangerous to introduce problems involving modern industrial ideas in which the student has had no proper foundation. Any change in this direction can only consist of the substitution of new names and relations for the old ones, as amperes of current or volts of E. M. F. for yards of cloth. The mathematical processes to be illustrated are not different from what they were a hundred years ago. Good mathematicians were developed on problems of the old type such as Newton, the creator of modern dynamics, Gauss, one of the founders of modern electrical science, Lagrange, Laplace, and many others to whom modern mathematicians must still look up. A moderate use of problems which introduce a few modern scientific and industrial terms may serve the double purpose of adding interest and making the pupil familiar with those terms, but they are no better for mathematical training than problems of the old type.

Of vastly greater importance are changes which tend to narrow the gap between elementary and higher mathematics. Can we give the elementary student the idea that there is something for algebra to do besides find x? Elementary students manifest a decided weakness in their concepts of variation. Problems which deal with variables, such as the relative motions of the hands of a clock, are difficult for elementary students, because they have had no systematic discussion of the principles involved. The concept of independent and dependent variables, or of functions, should be developed by familiar illustrations both geometrically by graphs, and physically by simple motions. The topic of limits should not be introduced into an elementary course without some introductory treatment of variation which is orderly in character.

In conclusion, my advice to a high school which desires to adjust its course to the needs of a technical school is that a review in elementary algebra be given in the senior year, with special attention to clearness, neatness, and accuracy, in the fundamental operations. If there is time, a similar review of elementary arithmetic and geometry, consisting mainly of a course of original exercises, would be useful.

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